

# LIQUID CRYSTAL DISPLAY HAVING DUAL SHIFT CLOCK WIRE

## BACKGROUND OF THE INVENTION

### (a) Field of the Invention

The present invention relates to a liquid crystal display, and more particularly to a liquid crystal display having a dual shift clock wire.

### (b) Description of the Related Art

FIG. 1 shows a block diagram of a conventional thin film transistor liquid crystal display TFT-LCD. The conventional TFT-LCD includes an LCD panel 10, a data driver 20, a gate driver 30 and a timing controller 40. A plurality of gate lines (not shown), or scanning lines, are formed in parallel on the LCD panel 10, and a plurality of data lines (not shown) perpendicularly intersect the gate lines insulated from the gate lines. Further, pixel electrodes are formed at the intersection of data lines and the gate lines. A thin film transistor (TFT), which acts as a switching device, is formed at each of the pixels. A gate electrode, a source electrode and a drain electrode of the TFT is respectively connected to a gate line, a data line and a pixel electrode.

The data driver 20 is electrically connected to the data lines of the LCD panel 10. After receiving digital signals of R,G,B data and control signals from the timing controller 40, the data driver 20 outputs corresponding R,G,B data voltages, which are analog signals, to each data line of the LCD panel 10. If the data driver 20 is designed in a single integrated circuit to connect the data lines, the integrated circuit chip needs a large number of output pins. Therefore, the data driver 20 is comprised of a plurality of data driver ICs 20a, 20b, 20c and 20d connected to the data lines.

The gate driver 30 is electrically connected to the gate lines of the LCD panel 10 and applies voltages successively to the gate lines to turn on the TFTs. If a TFT connected to one of the gate lines is turned on by the gate voltage, the data voltages applied to the data lines are transmitted to the pixel electrodes through the drain electrodes of the TFTs. Like the data driver 20, the gate driver 30 is also comprised of a plurality of gate driver ICs 30a, 30b, 30c and 30d.

The timing controller 40 outputs R,G,B data signals to the data driver 20 and various timing signals to the data driver 20 as well as to the gate driver 30. The timing controller 40 is provided on a printed circuit board PCB 50 separated from the data driver 20 and the gate driver 30. Further, various timing signals and R,G,B data signals from the timing controller 40 are transmitted to the data driver 20 and the gate driver 30 through wires formed on the PCB 50. Among the signals from the timing controller 40 to the data driver 20 are data signals and a shift clock signal for storing the data signals in a shift register (not shown) of the data driver 20.

Since the frequency of the shift clock signal exceeds 65MHz in an XGA-class TFT-LCD, electromagnetic interference (EMI) occurs when the shift clock signal is transmitted to the data driver ICs 20a, 20b, 20c and 20d through the wires of the PCB 50. This is compounded by the fact that the wires of the timing controller 40 transmitting the shift clock signal must be long enough to connect each of the data driver ICs 20a, 20b, 20c and 20d located along the length of the data driver 20 connecting the data lines of the LCD panel 10 (lengths of the LCD panel 10, the data driver 20 and the PCB 50 are substantially identical). That is, the clock signal is transmitted through an extensive distance, causing an increased generation of EMI.

## SUMMARY OF THE INVENTION

The present invention has been made in an effort to solve the above problem.

It is an objective of the present invention to provide a liquid crystal display having a dual shift clock wire that reduces EMI arising from the transmission of high-speed shift clock signals and data signals.

5 To achieve the above objective, the present invention provides a liquid crystal display. The LCD includes an LCD panel having a plurality of data lines, a plurality of gate lines intersecting the data lines in a substantially perpendicular manner, and a plurality of pixel electrodes arranged in a matrix configuration and each having a switch connected to one of the gate lines and one of the data lines; a gate driver for successively applying a gate voltage to the gate lines to turn on the switches; a data driver for applying a gray voltage, corresponding to image data signals, to the data lines; and a printed circuit board having a timing controller for generating both the image data signals and the shift clock signal shifting the image data signals to the data driver, a first signal wire through which the shift clock signal is transmitted, and a second signal wire through which a first clock signal with the same frequency as the shift clock signal and phase difference of  $90^\circ$  to  $270^\circ$

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SUBC27  
According to a feature of the present invention the second signal wire is grounded with a predetermined resistance value.

20 According to another feature of the present invention, the first clock signal is generated in the timing controller.

According to yet another feature of the present invention, the printed circuit board is multi-layered and the first signal wire and the second signal wire are formed in

parallel on the same layer.

According to still yet another feature of the present invention, the printed circuit board is multi-layered and the first signal wire and the second signal wire are formed on different layers.

5 According to still yet another feature of the present invention, the first clock signal has a phase difference of  $180^\circ$  compared to the shift clock signal.

According to still yet another feature of the present invention, the data driver comprises a plurality of data driver integrated circuits that receive the image data signals and the shift clock signal from the timing controller and applies the gray voltage corresponding to the image data signals to the data lines of the LCD panel.

10 According to still yet another feature of the present invention, the data driver integrated circuits include a shift register that shifts and stores the image data signals received from the timing controller in synchronization with the shift clock signal; a D/A converter receiving the image data signals stored in the shift register and converting the image data signals to a corresponding gray voltage; and an output buffer for temporarily storing the gray voltage output from the D/A converter, and applying the gray voltage to the data lines of the LCD panel in units of lines.

15 In another aspect, the printed circuit board includes a timing controller. It generates first and second image data signals and first and second shift clock signals having a phase difference of  $90^\circ$  to  $270^\circ$ . The first and second shift clock signals respectively shift the first and second image data signals. The printed circuit board also includes first and second image data signal wires through which the first and second image data signals are respectively transmitted, and first and second shift clock signal

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wires through which the first and second shift clock signals are respectively transmitted. The data driver receives the first and second image data signals and the first and second shift clock signals from the timing controller, and applies gray voltages corresponding to the first and second image data signals to the data lines.

5           According to the present invention, the first image data signals are odd image data signals, and the second image data signals are even image data signals.

          According to another feature of the present invention, the first and second shift clock signals have a phase difference of  $180^\circ$ .

10           According to yet another feature of the present invention, the first and second image data signals have a phase difference of  $90^\circ$  to  $270^\circ$ .

          According to still yet another feature of the present invention, the first and second image data signals have a phase difference of  $180^\circ$ .

15           According to still yet another feature of the present invention, the first image data signal is synchronized to a rising edge of the first shift clock signal, and the second image data signals is synchronized to a falling edge of the second shift clock signal.

          According to still yet another feature of the present invention, a pulse width of the first and second shift clock signals falls within a high signal interval or a low signal interval of the odd and even image data signals.

20           According to still yet another feature of the present invention, the first and second image data signals have a phase difference of  $90^\circ$  or  $270^\circ$ .

### **DESCRIPTION OF THE DRAWINGS**

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate an embodiment of the invention, and, together with the

description, serve to explain the principles of the invention:

FIG. 1 is a block diagram of a conventional TFT-LCD;

FIG. 2 is a schematic view of a TFT-LCD according to a first preferred embodiment of the present invention;

FIG. 3 is a cross-sectional view taken along line A-A' of FIG. 2;

FIG. 4 is a detailed block diagram of a data driver IC shown in FIG. 2;

FIG. 5 is a time chart of clock signals according to the first preferred embodiment of the present invention;

FIG. 6 is a schematic view of a TFT-LCD according to a second preferred embodiment of the present invention;

FIG. 7 is a time chart of image data signals and shift clock signals according to the second preferred embodiment of the present invention;

FIGs. 8 and 9 are time charts of image data signals and shift clock signals according to a third preferred embodiment of the present invention; and

FIG. 10 is a time chart of image data signals and shift clock signals according to a fourth preferred embodiment of the present invention.

### **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Preferred embodiments of the present invention will now be described in detail with reference to the accompanying drawings.

FIG. 2 shows a schematic view of a TFT-LCD according to a first preferred embodiment of the present invention. The TFT-LCD according to the first preferred embodiment of the present invention includes an LCD panel 100, a data driver 200, a gate driver 300 and a timing controller 550. The LCD panel 100 is comprised of a color

filter substrate 110 and a TFT substrate 120, and a liquid crystal layer injected between the substrates 110 and 120. Also, the timing controller 550 is provided on a first PCB 500, and a gate driver 300 is electrically connected to a second PCB 400.

5 Formed on the color filter substrate 110 are common electrodes (not shown) which receive a common voltage, and a R,G,B color filter layer (not shown). Formed on the TFT substrate 120 are a plurality of parallel gate lines Gn, or scanning lines, and a plurality of parallel data lines Dm that receive image signals. The gate lines Gn are laid substantially perpendicular to the data lines Dm in an insulated manner. Also, pixel electrodes are formed at corresponding areas where the data lines Dm intersect the gate lines Gn, and a thin film transistor (TFT) 125, which acts as a switching device, is formed at each of the pixels.

10 Each TFT 125 has a gate electrode, a source electrode and a drain electrode, each of which is respectively connected to one of the gate lines Gn, one of the data lines Dm and one of the pixel electrodes. A liquid crystal layer is injected between the pixel electrodes of the TFT substrate 120 and the common electrodes of the color filter substrate 110, where the liquid crystal layer, pixel electrode and the common electrode form a liquid crystal capacitor Cl. Further, a storage capacitor Cst is formed in the pixel electrode for storing the voltage charged in the liquid crystal.

15 The data driver 200 includes a plurality of data driver ICs 200a, 200b, 200c and 200d which are mounted on tape carrier plates TCPs 250a, 250b, 250c and 250d, respectively. In addition, formed on each of the TCPs 250a, 250b, 250c and 250d is a first signal wire for interconnecting the first PCB 500 to the data driver ICs 200a, 200b, 200c and 200d; and second signal wires for interconnecting groups of data pads 127a,

127b, 127c and 127d, formed at the ends of the data lines Dm of the TFT substrate 120, with the data driver ICs 200a, 200b, 200c and 200d.

FIG. 3 shows a cross-sectional view taken along line A-A' of FIG. 2. In the drawing, although only the TCP 250a and the data driver IC 200a are illustrated, it is to be assumed that the description and configuration for the remainder of the TCPs 250b, 250c and 250d, and the data driver ICs 200b, 200c and 200d, in addition to all related elements, are identical. The TCP 250a electrically connects both the LCD panel 100 and the first PCB 500 to the data driver IC 200a. Also shown in the drawing, liquid crystal material 104 is injected between the TFT substrate 120 and the color filter substrate 110, and the liquid crystal material 104 is sealed therein by the formation of a sealant 106 between the substrates 110 and 120.

A first anisotropic conduction film (ACF) 270a is formed on the data pad 127a, located at the end of the data line Dm of the TFT substrate 120 as described above. The first ACF 270a adheres to the TCP 250a thereby electrically connecting the data pad 127a to the data driver IC 200a. Further, the TCP 250a is connected to the first PCB 500 to transmit various signals received from the timing controller 550 to the data driver IC 200a. As shown in the drawing, a second ACF 290a is interposed between the TCP 250a and the first PCB 500. Here, it is also possible to simply solder the TCP 250a to the first PCB 500.

Each of the data driver ICs 200a, 200b, 200c and 200d receives R,G,B data signals, shift clock signals and control signals coming from the timing controller 550 and applies them as R,G,B data voltage, or analog signals, to each data line of the TFT panel 120. As shown in FIG. 4, the data driver IC 200a, which is identical in structure



and operation to the other data driver ICs 200b, 200c and 200d, is comprised of a shift register 210a, a D/A (digital/analog) converter 220a and an output buffer 230.

The shift register 210a of the data driver IC 200a receives R,G,B data transmitted from the timing controller 550, and shifts the R,G,B data in sequence and stores them in synchronization with a first shift clock signal CLK1. After all the data have been stored in the shift register 210a of the data driver IC 200a, the data driver IC 200a outputs a carry out signal to the subsequent data driver IC 200b (see FIG. 2) which performs the same operation as the previous data driver IC 200a. In this way, the remainder of the data driver ICs 200c and 200d (see FIG. 2) execute the same shifting, storing and outputting operation as the data driver IC 200a.

The D/A converter 220a converts the data signals stored and transmitted by the shift register 210a to corresponding gray voltage values. In more detail, the D/A converter 220a receives both gray voltages ( $V_1, V_2, \dots, V_n$ ) from a gray voltage generator (not shown) and the data signals from the shift register 210a, and generates analog gray voltage values corresponding to the data signals stored in the shift register 210a.

The output buffer 230a of the data driver IC 200a stores the analog gray voltage values from the D/A converter 220a, and if a LOAD signal is applied to the output buffer 230a, the analog gray voltage values are applied to each of the data lines electrically connected to the data driver IC 200a.

Referring back to FIG. 2, the gate driver 300 is electrically connected to the gate lines of the TFT substrate 120. The gate driver 300 includes a plurality of TCPs 350a, 350b and 350c on which are mounted gate driver ICs 300a, 300b and 300c,

respectively. Through the TCPs 350a, 350b and 350c, the gate driver ICs 300a, 300b and 300c are electrically connected to groups of gate pads 128a, 128b and 128c, formed at the ends of the gate lines Gn, and to the second PCB 400. With this structure, the gate driver 300 successively applies gate ON voltage to the gate lines to turn on the TFTs 125. If one of the TFTs 125 connected to one of the gate lines is turned on by the gate ON voltage, the data voltage applied to the data lines is transmitted to the pixel electrodes via the drain electrodes of the TFTs 125.

The timing controller 550 outputs R,G,B data signals and various timing signals to the data driver 200 and the gate driver 300. As described above, the timing controller 550 is formed on the first PCB 500 of a multi-layered substrate. The timing controller 550 outputs the R,G,B data signals and timing signals via wires formed in the first PCB 500. Referring to FIG. 5, when transmitting the first shift clock signal CLK1 to the data driver ICs 200a, 200b, 200c and 200d, a second shift clock signal CLK2, which has the same frequency as the first shift clock signal CLK1 but has an opposite phase is sent to a ground GND via a resistor Re to minimize EMI caused by the transmission of the first shift clock signal CLK 1. A dummy wire is provided on the first PCB 500 parallel to the wire used for the first shift clock signal CLK1, and the second shift clock signal CLK2 is output from the timing controller 550 to the ground GND through the dummy wire to offset the EMI caused by the transmission of the first shift clock signal CLK1.

EMI, typically generated in TFT-LCDs during the transmission of high frequency signals, comes from a strip-type high frequency wire and a ground surface area adjacent to this wire. The electric field generated between the high frequency wire and

the ground surface area accumulates in the ground surface area electric charges with a polarity opposite to the high frequency wire. The strength of EMI is directly proportionate to the current flowing on the ground surface, which depends on the movement of the electric charges. Therefore, EMI can be reduced by minimizing the amount of the current fluctuation on the ground surface.

In the TFT-LCD according to the first preferred embodiment of the present invention, the second shift clock signal CLK2, having the same frequency as the first shift clock signal CLK1 but an opposite phase, is sent to the ground GND via the resistor Re as described above. As a result, electric charges of an opposite polarity are induced in the ground surface areas of the transmission pathway of the first shift clock signal CLK1 and the second shift clock signals CLK2 such that the electric charges offset each other. The reduction of the current on the ground surface area corresponding to the first shift clock signal CLK1, minimizes the EMI.

In the first preferred embodiment of the present invention, the second shift clock signal CLK2 is output from the timing controller 550 like the first shift clock signal CLK1, but may come from a separate IC other than the timing controller 550. Further, it is preferable that the wires for the first shift clock signal CLK1 and the second shift clock signal CLK2 are parallel and formed on an identical layer of the first PCB 500. However, it is also possible to form the first shift clock signal CLK1 and the second shift clock signal CLK2 on different layers of the first PCB 500. Further, the first shift clock signal CLK1 and the second shift clock signal CLK2 may have opposite phases (by a phase difference of  $180^\circ$ ) as described above, or may have a phase difference of  $90^\circ$  to  $270^\circ$ .

A TFT-LCD according to a second preferred embodiment of the present invention is now described in detail hereinafter.

FIG. 6 shows a schematic view of a TFT-LCD according to a second preferred embodiment of the present invention. Like reference numerals will be used for elements identical in operation and structure to the elements of the first preferred embodiment. The TFT-LCD according to the second preferred embodiment of the present invention comprises an LCD panel 100, a gate driver 300, a data driver 600 and a timing controller 750, the timing controller 750 being provided on a PCB 700. Since the LCD panel 100 and the gate driver 300 are identical in structure and operation to that of the first embodiment, a description thereof will be omitted.

Referring to the drawing, the timing controller 750 transmits odd image data signals, applied to odd data wires (not shown) of the LCD panel 100, and even image data signals, applied to even data wires (not shown) of the LCD panel 100, to data driver ICs 600a, 600b, 600c and 600d of the data driver 600 through an odd wire L1 and an even wire L2, respectively. Further, third and fourth shift clock signals CLK3 and CLK4, to which the image data signals are synchronized, are sent from the timing controller 750 to the data driver ICs 600a, 600b, 600c and 600d of the data driver 600 respectively through first and second clock wires D1 and D2. That is, the timing controller 750 sends the odd image data signals and the third shift clock signal CLK3 respectively through the odd wire L1 and the first clock wire D1 to both the data driver ICs 600a and 600c. Also it sends the even image data signals and the fourth shift clock signal CLK4 respectively through the even wire L2 and the second clock wire D2 to both the data driver ICs 600b and 600d.

Since the image data signals are divided into two groups and output to the data driver ICs 600a, 600b, 600c and 600d as described above, frequencies of the image data signals and the shift clock signals CLK3 and CLK4 are reduced in half compared to the TFT-LCD of the first preferred embodiment. As a result, EMI is reduced.

FIG. 7 shows a time chart of the odd and even image data signals and the shift clock signals CLK3 and CLK4 according to the second preferred embodiment of the present invention. As shown in the drawing, both the third and fourth shift clock signals CLK3 and CLK4, and the odd and even image data signals have the same frequency but opposite phases. The odd image data signals are synchronized to a rising edge of the third shift clock signal CLK3 and stored in shift registers (not shown) of the data driver ICs 600a and 600c, while the even image data signals are synchronized to a falling edge of the fourth shift clock signal CLK4 and stored in shift registers (not shown) of the data driver ICs 600b and 600d. Accordingly, the data driver ICs 600a, 600b, 600c and 600d of the second embodiment must have the capability to select whether to synchronize to the rising edge or the falling edge of the shift clock signals CLK3 and CLK4, i.e. a positive clock triggering or a negative clock triggering.

The TFT-LCDs according to a third embodiment and a fourth embodiment of the present invention solve such a clock triggering problem. FIGs. 8 and 9 show time charts of odd and even image data signals, and shift clock signals CLK3 and CLK4 according to a third preferred embodiment of the present invention. FIG. 10 shows a time chart of odd and even image data signals, and shift clock signals CLK3 and CLK4 according to a fourth preferred embodiment of the present invention. In the third and fourth embodiments, the shift clock signals CLK3 and CLK4, and the odd and even

image data signals are the same as those generated from the timing controller 750 of the second preferred embodiment of the present invention.

Referring first to FIG. 8, both third and fourth shift clock signals CLK3 and CLK4, and the odd and even image data signals have identical frequencies but opposite phases. In this embodiment, a pulse width of each of the third shift clock signal CLK3 and the fourth shift clock signal CLK4 falls within a high (or low) signal interval of the odd image data signals and the even image data signals. Accordingly, the odd image data signals are synchronized to a rising edge of the third shift clock signal CLK3 and the even image data signals are synchronized to a falling edge of the fourth shift clock signal CLK4. Those image data signals are stored in the shift registers of the data driver ICs 600a, 600b, 600c and 600d. As a result, the data driver ICs 600a, 600b, 600c and 600d do not require the capability to perform a positive clock triggering and a negative clock triggering. Instead, a driver IC with only a positive clock triggering mode can be used.

FIG. 9 shows pulse widths of the shift clock signals CLK3 and CLK4 reduced by half. A reduction of the pulse width may improve a timing margin for the data driver ICs 600a, 600b, 600c and 600d.

Referring to FIG. 10, the third shift clock signal CLK3 and the fourth shift clock signal CLK4 have identical frequencies but opposite phases. However, although odd image data signals and even image data signals also have identical frequencies, there is a 90° phase difference. Because of this 90° phase difference, the odd and even image data signals are synchronized to rising edges (or falling edges) of the third and fourth shift clock signals CLK3 and CLK4 and stored in the shift registers of the data

driver ICs 600a, 600b, 600c and 600d. As a result, the data driver ICs 600a, 600b, 600c and 600d do not require the capability of a positive clock triggering and a negative clock triggering. As in the third embodiment, a driver IC with only a positive clock triggering mode can be used.

5           The present invention is not limited to the preferred embodiment as described above. For example, in the second preferred embodiment, various phase differences of 90° to 270°, other than only 180° can be used for the shift clock signals CLK3 and CLK4. Further, in the second preferred embodiment, having the phases of the shift clock signals CLK3 and CLK4 the same, a shift clock signal with a phase opposite to the shift clock signal CLK3 and CLK4 may be transmitted to a ground via separate wires, like the first embodiment. Further, in the preferred embodiments, the signal wires may be provided on a circuit board other than the printed circuit board. For example, the signal wires may be provided on a glass, substrate and flexible circuit board, etc.

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15           In the TFT-LCD according to the preferred embodiments of the present invention, the transmission of shift clock signals having opposite phases are transmitted, EMI caused by the shift clock signals is reduced by transmitting shift clock signals of opposite phases. EMI is further reduced with the transmission of the odd and even image data signals of opposite phases through separate signal wires.

20           Although preferred embodiments of the present invention have been described in detail hereinabove, it should be clearly understood that many variations and/or modifications of the basic inventive concepts herein taught shall fall within the spirit and scope of the present invention, as defined in the appended claims.